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**PORT WASHINGTON, L.I., N.Y.**

TECHNICAL REPORT - SPECDEVGEN 104-2-35

THE EQUATING OF READING MATERIALS FOR VOCAL  
RATE-DURATION AND INTENSITY

PREPARED BY:

Bernard Spilka  
M. D. Steer  
Director


Purdue University  
Lafayette, Indiana

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For the Special Devices Center:

Distribution by request

  
Harry Sosnoski, Captain, USN  
Commanding Officer and Director

## FOREWORD

### Purpose

In certain research studies designed to investigate the various speech variables which contribute to effective voice communication, it occasionally becomes mandatory that the reading materials used be equivalent. A survey of the literature indicates that reading materials of this nature are not currently available. Consequently, this study was undertaken to determine the equivalence of selected reading passages considered to be phonetically balanced with respect to the following voice variables:

1. Rate-duration as measured by the Percent Phonation Time and Average Syllable Duration.
2. Intensity as measured by the Mean Vocal Intensity and the Vocal Intensity Variance.

### Results

The results obtained from 128 adult male college students are as follows:

1. All eight passages investigated were equivalent in Mean Vocal Intensity.
2. Seven passages (all except Passage H) were equivalent in Mean Syllable Duration.
3. Six passages (all except Passages F and H) were equivalent in Percent Phonation Time.
4. Seven passages (all except Passage E) were equivalent in Vocal Intensity Variance.

### Implications

Speech intelligibility has been regarded as a problem in voice communication especially where transmission is difficult and information is of vital importance. Studies of voice communication often require

reading materials which are equated with respect to characteristics of speech and voice which are related to speech intelligibility. This study provides the first data with respect to equating voice variables of relatively long, continuous reading materials. These reading materials should become a valuable asset to future research on specific problems of voice communication.

John E. Murray  
Project Engineer

James J. Regan  
Head, Equipment Branch

C. P. Seitz, Ph.D.  
Head, Psychological Research  
and Development Division

## INTRODUCTION

For several years, voice scientists have recognized the need for speech materials which are equated with respect to various measures of speech. One of the earliest attempts to develop such materials resulted in the construction of reading passages considered to be "phonetically balanced", i.e., equivalent in phonetic structure. Another expression of this trend is found in the speech intelligibility tests constructed at the Waco Voice Communication laboratory (5). Recently, Black (1,4) has published lists of short phrases and sentences accompanied by various measures of vocal rate-duration and intensity obtained from subjects reading these materials.

The present study may be considered to be an extension of Black's work, since its purpose is to determine if reading passages which are considered to be either phonetically balanced or which are generally used as such are equivalent with respect to measures of vocal rate-duration and intensity.

## PROCEDURE

### Subjects

The subjects for this investigation were 128 male undergraduate students enrolled in an elementary course in public speaking.

### Instrumentation

The instruments which were used for recording and measuring the speech samples studied in this investigation were: (1) a Magnecord Corporation high fidelity magnetic tape recorder with type PT6-AH re-

cording unit and type PT6-J amplifier (complete unit known as the Magnecorder); (2) a McIntosh Engineering Laboratory amplifier type 20W-2 and McIntosh amplifier equalizer unit type AE-2A; (3) an Altec Lansing Corporation M11 microphone system with Altec 21B miniature condenser microphone; (4) two Hewlett-Packard Corporation 110 decibel single step attenuators, model 350A; (5) a Sound Apparatus Company High Speed Power Level Recorder, Model HPL-E; (6) Purdue Speech Sound Timer; (7) three headsets, type ANB-H-1; and (8) one Astatic Corporation crystal microphone, type JT-30. A block diagram of the circuit containing the above instruments may be seen in Figure 1.

#### Reading Passages

The following eight reading passages, ranging from 73 to 259 words (98 to 359 dictionary syllables) in length were used in this study and are presented in appendix A:

#### Passage

- A. My Grandfather
- B. The Rainbow
- C. The Navy
- D. The Boy and Eggs
- E. Farming
- F. Travel
- G. The Fire
- H. Arthur, The Young Rat

#### Method

Each subject was brought into a sound-treated room and seated in a tablet armchair. The Altec microphone used for recording was mounted in an adjustable bracket attached to the tablet arm of the chair and placed three to four inches in front of the subject's mouth. Throughout the recording session, the subject was instructed to hold this distance constant. The passage read by the subject was placed on a clipboard mounted above the

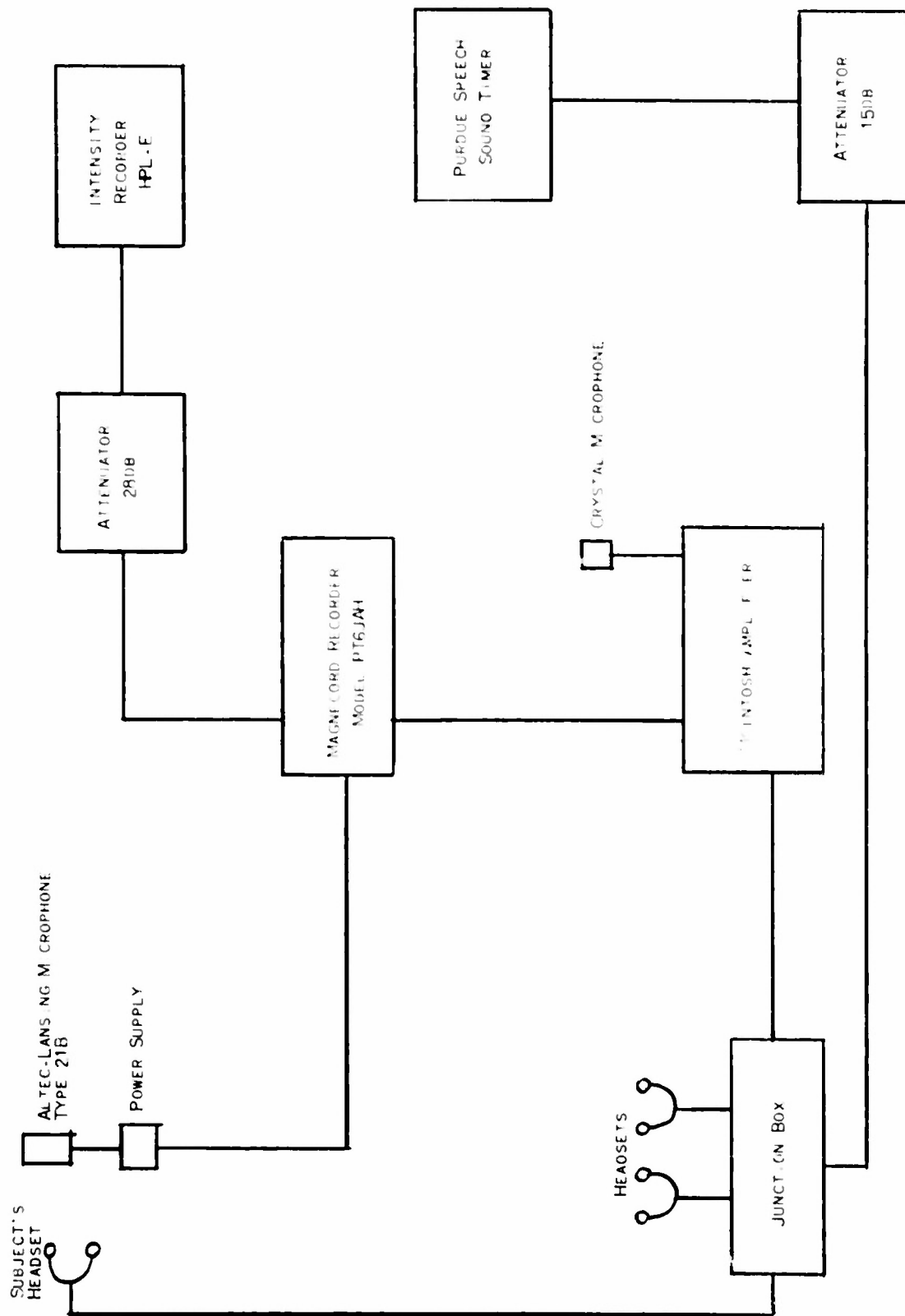


FIGURE 1 BLOCK DIAGRAM OF RECORDING AND INSTRUMENTATION FOR VOICE VARIABLE MEASUREMENTS



microphone. The subject wore headphones which were mounted in a pilot's helmet in order to prevent leakage from the phones to the microphone, and, thus, the establishment of a continuous feedback loop. Sidetone intensity was set 40 to 50 decibels above the subject's speaking level to meet the requirements of a larger research project of which this study was a part. An evaluation of the possible effects of this condition is presented in the discussion of results.

Following the initial instruction period, the experimenter moved to the sound-treated room which contained the recording and analyzing equipment. Contact with the subject was maintained by means of the circuit shown in Figure 1.

The following instructions were then given to each subject:

"Check to see that you are always three to four inches from the microphone. I should now like you to read the passage which is before your eyes. Beginning with the introductory sentence, 'My name is ...', read the passage through in your normal speaking manner so that I can make the adjustments necessary for recording you. Please begin now with 'My name is ...

During this first reading, the experimenter set the gain control for the Magnecord so that the majority of the subject's vocal intensity peaks fell between the -1 and +1 marks on the Magencorder Volume Unit meter. This gain control setting was then recorded. This practice reading, in addition to permitting the experimenter to set an intensity level for recording the subject, also served to familiarize the subject with the reading passage, thus, reducing the occurrence of hesitancies and articulation errors.

After the first reading, the subject was given the following instructions:

"Check again to see that you are three to four inches from the microphone. I should now like you to reread the passage in the exact same way that you just read it, and I shall make my

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recordings of your voice. Begin now with 'My name is ...

As soon as the subject had stated his name, the experimenter set the High Speed Power Level Recorder and the Purdue Speech Sound Timer into operation (Figure 1). When the subject finished reading the passage, these instruments were turned off and the data were recorded. This concluded the testing session for each subject.

In this investigation, the measures of vocal rate-duration used were percent phonation time (actual speaking time) and mean syllable duration; the measures of vocal intensity were mean vocal intensity and intensity variance.

The rate-duration measures were based on dial readings from the Purdue Speech Sound Timer. One dial of this instrument indicates total time taken for reading the passage and the other dial indicates the actual time during which phonation occurs. Percent phonation time is a function of the phonation-time total-time ratio; mean syllable duration is the ratio of the number of dictionary syllables to the phonation time.

The intensity measures were derived from the continuous tape recording of the Sound Apparatus Company's High Speed Power Level Recorder, Model HPL-E. (All readings were converted to decibels above .0002 dynes/cm<sup>2</sup>.) Mean vocal intensity was calculated by measuring the extent of each intensity peak and computing the mean of these peaks. Intensity variance is the variance of the peak intensities around the mean vocal intensity.

#### Statistical Analysis

The criteria for equivalence are that the reading passages have equal means and equal variances with respect to percent phonation time, mean syllable duration, mean vocal intensity, and intensity variance. These criteria were initially investigated by the  $L_0$  test (7) which evaluates

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the composite hypothesis that the means and variances are equal for each of the variables considered.<sup>1</sup>

Further analysis of the data was indicated by the outcome of this test as follows:

(1) If  $L_0$  reached the critical five percent level, it was not known whether the difference was due to the means, the variances or both. Thus, tests for the homogeneity of variances ( $L_1$  test) were conducted since the analysis for differences among means assumes that the variances are equal.

(a) If the  $L_1$  test reached the critical level, it was necessary to reject the hypothesis of equal variances (homogeneity). In this case, the most deviant variance would be dropped and the test conducted on the basis of the remaining data.

(b) If homogeneous variances were indicated by the  $L_1$  test, a single classification analysis of variance (6) was used for differences among means. Where differences were found, a comparison of individual means was conducted to determine which reading passages were deviant for each of the four voice variables. To accomplish the comparison of passage means, the methods developed by Tukey (9) and Newman (8) were employed.

(2) If  $L_0$  did not reach the critical point, further statistical testing was not necessary since the means and variances were not shown to be statistically different.

To satisfy the assumption of normality underlying the statistical techniques used in this study, the data for vocal intensity variance were initially transformed to a logarithmic scale.

## RESULTS AND DISCUSSION

Caution should be used in generalizing from these results since the feedback level was at a different intensity level than that used in normal speech. However, studies conducted by Black and his associates (2,3) relating intensity level of auditory stimuli to voice variables suggest that changes in speech will remain fairly constant as the intensity of sidetone varies for similar reading materials. Thus, it appears that reading passages equated at one level of auditory feedback will probably remain equivalent over a wide range of feedback levels.

The means and standard deviation for each measure of the eight passages are presented in Tables 1 and 2. (See Appendix B).

The  $L_0$  tests reached the critical point for all the voice variables except mean vocal intensity (Table 3) indicating the necessity for further analysis on percent phonation time, mean syllable duration and intensity variance. All of the variance tests ( $L_1$ ) for these variables failed to reach the critical point; and, therefore, it was possible to accept the hypothesis that the variances were homogeneous for these three variables.

Since all of the  $L_1$  ratios failed to reach the critical point, it must be assumed that the differences indicated by the  $L_0$  ratios for percent phonation time, mean syllable duration, and intensity variance were a function of differences among means. Single classification analyses of variance were conducted and shown to have unequal means on the three variables. The results of these analyses are shown in Tables 4, 5, and 6.

In order to determine which passages were homogeneous with respect to the mean scores for the different voice variables, a number of tests to

compare these means were applied (8,9). In the case of mean syllable duration and vocal intensity variance, the procedure developed by Tukey (9) revealed significantly different passage means. Passage H was found to be the deviant mean on mean syllable duration and Passage E on intensity variance. Because the Tukey technique failed to isolate any deviant means in the case of percent phonation time, Newman's procedure (8) was used. As may be seen in Table 7, Newman's test demonstrated that the significant F-ratio obtained for percent phonation time was caused by the deviation of passages F and H. A homogeneous set of passage means was thus obtained by removing Passages F and H.

#### SUMMARY AND CONCLUSIONS

An investigation was conducted to select reading passages considered to be equivalent with respect to the voice variables of percent phonation time, average syllable duration, mean vocal intensity, and vocal intensity variance. One hundred and twenty-eight young adult college males took part in this study. Eight reading passages were chosen for analysis and 16 subjects read each of the passages. Recordings of the passage readings were analyzed by means of the Purdue Speech Sound Timer and the Sound Apparatus Company's High Speed Power Level Recorder, Model HPL-E. The results of the analysis may be summarized as follows:

1. All eight passages were found to be homogeneous with respect to their means and variances of mean vocal intensity.
2. Seven of the reading passages (all except Passage H) were found to be equated in their means and variances of mean syllable duration.
3. Six of the reading passages (all except F and H) were found to be equivalent with respect to their means and variances of percent

phonation time.

4. Seven of the reading passages (all except E) were found to be equivalent with respect to their means and variances of the vocal intensity variance.

Within the limits of the present study, reading materials equated with respect to the studied voice variables have been demonstrated. As far as is known from the surveyed literature, this research presents the first data with respect to equating voice variables in fairly long, continuous reading materials.

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APPENDIX A

EIGHT READING PASSAGES INVESTIGATED IN THIS STUDY



PASSAGE A

My Grandfather

My name is \_\_\_\_\_, and the passage I am going to read begins . . . You wished to know all about my grandfather. Well, he is nearly ninety-three years old; he dresses himself in an ancient black frockcoat, usually minus several buttons; yet he still thinks as swiftly as ever. A long flowing beard clings to his chin, giving those who observe him a pronounced feeling of the utmost respect. When he speaks, his voice is just a bit cracked and quivers a trifle. Twice each day he plays skillfully and with zest upon the small organ. Except in the winter when the ooze or snow or ice prevent, he slowly takes a short walk in the open air each day. We have often urged him to walk more and smoke less but he always answers, "Banana oil!" Grandfather likes to be modern in his language.

## PASSAGE B

The Rainbow

My name is \_\_\_\_\_, and the passage I am going to read begins . . . When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

PASSAGE C

The Navy

My name is \_\_\_\_\_, and the passage I am going to read begins . . . The navy was once made up of wooden ships with cloth sails. Then came iron ships, but the sails were still of cloth. When the wind blew, the navy could attack. Years later boilers and engines were invented and sailors could strike their enemies at will. You might think it easy to figure out each new idea, but changes come slowly. Not little changes but great changes are a measure of our progress.

## PASSAGE D

Boy and Eggs

My name is \_\_\_\_\_, and the passage I am going to read begins . . . One day a long time ago a little boy was sent to town to sell a basket of butter and eggs. His mother said, "Go straight to town and do not stop on the road." Soon the little boy came to a river. Because he did not want to get his feet wet, he sat down on the bank. "What shall I do?" thought the boy. "The river is very wide. I can't jump across, so I will wait for it to pass by." So he sat down and waited all day for the water to pass by. At last the sun set. When it grew almost dark, the little boy became frightened and took the basket and ran home to his mother. "What does this mean?" asked his mother. "Why did you stay so long? And why didn't you sell your butter and eggs?" "I came to a river, Mother," said the boy. "I didn't want to get my feet wet. The river was very wide. I couldn't jump across. So I sat down to wait until the water had passed by. But it is running there still." "You will never sell your butter and eggs," said his mother, "if you wait until all of the water in the river has passed by. It will be running long after you and I are dead."

PASSAGE E

Farming

My name is \_\_\_\_\_, and the passage I am going to read begins . . . In the spring, men begin to work the soil. Those who have small gardens spade up the ground. This is a very hard job. Those who live on farms turn the soil over with plows drawn by tractors. In these ways the soil is made loose and soft, so that seeds and plants can grow in it. After the planting is done, the weeds should be killed and the soil must be kept loose. Later, the crops are ready to gather. This is the harvest season. The men often begin work at four or five o'clock in the morning, and sometimes do not stop before dark. They raise much more than they need for themselves, and what they do not want they sell. People who live in the city use the things that are grown on farms. Make a list of the different kinds of food that you eat in one day and find how many of them have come from farms. Many men are kept busy raising the food people eat. In some farming zones, the crops raised are changed from year to year.

PASSAGE F

Travel

My name is \_\_\_\_\_, and the passage I am going to read begins . . . The principle means of transportation available in this twentieth-century are ships, trains, automobiles and airplanes. Each is constantly being improved. Ships are floating cities, trains are streamlined lounges, automobiles are livingrooms on wheels, and airplanes are box-cars with wings. They can satisfy every whim or wish of the traveler. For instance, do you like to ride through the country-side and gaze lazily at the scenery? Then take a train or bus. The former is recommended if your journey is long and involves a night on the road. If you prefer speed, a birds-eye view of the landscape, and the thrill that goes with flying, then take a plane.

Are you one who likes to stop everytime you feel so inclined? One who enjoys freedom of the highways? If so, travel by car, motorcycle, or jeep. But, here you have the responsibility of driving yourself. The prospect of getting lost, though confusing, may often be entertaining. The questions: where am I?, which way is Mulberry?, how do we get to route 66?, sometimes bring forth most astounding explanations. Then, there is also the possibility of meeting the man who too casually asks, "You didn't see that stop sign, did you?" or "May I see your driver's license?" Ah, yes, those are the perils of the road!

PASSAGE G

The Fire

My name is \_\_\_\_\_, and the passage I am going to read begins . . . Fire is one of man's best friends. Most people do not realize the benefits derived from fire. The caveman learned how to use fire in the cooking of his meat. He also used it to scare away ferocious animals. A glowing fire became a symbol for friendliness and comfort. Later man invented matches so he could carry fire in his pockets.

Today matches are used for many purposes; they are used to light candles, bonfires, cigarettes, pipes, and cigars.

Matches are very dangerous when they are not used properly. Mothers always say to children, "be careful when you use matches, won't you?" And the boys and girls always answer, "of course, mother." If a match is not properly struck it may burn you. Mary lighted a match and severely burned her finger. "Oh, oh, oh", she cried, "put some salve on it!" Mother said, "I told you to be careful, Mary."

Millions of dollars are lost every year because people are careless about fire. Thousands lose their lives because someone forgot to be careful. Acres and acres of oak, maple, pine and elm trees are burned each year because a tourist threw a burning match into the dry tinder. Always watch to see that you are careful about fire and you won't be responsible for loss of lives and property. When you see a sign in the forest that says "be careful with your cigarettes" or "break your match", you can realize that each one of us can help in fire prevention and save our beautiful trees and shrubs.

PASSAGE H

Arthur, The Young Rat

My name is \_\_\_\_\_, and the passage I am going to read begins . . . Once, a long time ago, there was a young rat named Arthur who could never make up his flighty mind. Whenever his swell friends use to ask him to go out to play with them, he would only answer airily, "I don't know." He wouldn't try to say yes, or no either. He would always shirk from making a specific choice. His proud Aunt Helen scolded him: "Now look here," she stated. "No one is going to aid or care for you if you carry on like this. You have no more mind than a stray blade of grass." That very night there was a big thundering crash and in the foggy morning some zealous men -- with twenty boys and girls --- rode up and looked closely at the fallen barn. One of them slipped back a broken board and saw a squashed young rat, quite dead, half in and half out of his hole. Thus, in the end the poor shirker got his just dues. Oddly enough his Aunt Helen was glad. "I hate such oozy, oily sneaks," said she.



APPENDIX B

STATISTICAL ANALYSIS OF THE DATA OBTAINED IN THIS STUDY  
ON THE VARIABLES INDICATED

TABLE I  
MEANS FORMED OF READING PASSAGES ON VOICE VARIABLES  
(N = 16)

VARIABLE				
Passage	Percent Phonation Time	Average Syllable Duration	Mean Vocal Intensity	Vocal Intensity Variance
A	40.621	.10906	13.875	1.514
B	39.916	.09406	13.681	1.569
C	41.070	.10793	16.743	1.583
D	45.773	.11556	17.700	1.538
E	41.932	.12200	15.441	1.463
F	39.297	.09975	14.944	1.552
G	46.657	.11762	14.931	1.524
H	48.433	.13237	14.512	1.483

TABLE 2  
STANDARD DEVIATIONS OF READING PASSAGES ON VOICE VARIABLES  
(N = 16)

VARIABLES				
Passage	Percent Phonation Time	Average Syllable Duration	Mean Vocal Intensity	Vocal Intensity Variance
A	9.57	.0336	5.86	.0960
B	7.60	.0199	3.31	.1030
C	7.40	.0203	5.85	.0991
D	7.63	.0247	4.61	.0881
E	5.62	.0214	4.34	.1085
F	11.57	.0253	4.00	.0862
G	9.44	.0306	3.69	.0446
H	4.97	.0180	4.10	.1332

TABLE 3  
RESULTS OF  $L_0$  AND  $L_1$  TESTS

Variable	$L_0, L_1$ Ratios	df	Significance
Percent Phonation Time	$L_0 = .7632$ $L_1 = .8878$	8,16	.06 N.S. <sup>1</sup>
Average Syllable Duration	$L_0 = .7550$ $L_1 = .9174$	9,16	.05 N.S.
Mean Vocal Intensity	$L_0 = .8600$ ( $L_1$ was not computed because of the lack of significance of $L_0$ )	8,16	N.S.
Vocal Intensity Variance	$L_0 = .7561$ $L_1 = .8766$	8,16	.05 N.S.

<sup>1</sup>N.S. indicates that the obtained ratio was not significant at the .05 level of confidence.

TABLE 4

RESULTS OF AN ANALYSIS OF VARIANCE OF PASSAGE MEANS FOR PERCENT  
PHONATION TIME

Source	Sums of Squares	Degrees of Freedom	Mean Square	F-Ratio	Sig.
Between Passages	1,349.139	7	192.734	2.669	.05
Within Passages	8,667.050	120	72.225		
TOTAL	10,016.189	127			

TABLE 5

RESULTS OF AN ANALYSIS OF VARIANCE OF PASSAGE MEANS FOR AVERAGE  
SYLLABLE DURATION

Source	Sums of Squares	Degrees of Freedom	Mean Square	F-Ratio	Sig.
Between Passages	.01689	7	.00241	3.684	.01
Within Passages	.07857	120	.00655		
TOTAL	.09545	127			

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TABLE 6  
RESULTS OF ANALYSIS OF VARIANCE OF PASSAGE MEANS FOR VOCAL  
INTENSITY VARIANCE

Source	Sums of Squares	Degrees of Freedom	Mean Square	F-Ratio	Sig.
Between Passages	.18999	7	.02714	2.684	.05
Within Passages	1.21365	120	.01011		
TOTAL	1.40364	127			

TABLE 7

RESULTS OF COMPARISONS AMONG PASSAGE MEANS UTILIZING THE PROCEDURES  
OF TUKEY AND NEWMAN

	Percent Phonation Time <sup>1</sup>	Average Syllable Duration	Vocal Intensity Variance
Standard Error of a mean	2.12 <sup>4</sup>	.006 <sup>4</sup>	.0261
Standard Error of a difference between 2 means	-----	.0091	.0356
t-ratio with extreme mean split off	4.301 <sup>4</sup>	2.65 <sup>3</sup>	1.97 <sup>2</sup>
Extreme mean passage (s)	F and H <sup>5</sup>	H	E
F-ratio between remaining passages	----- <sup>6</sup>	1.79	1.86

<sup>1</sup> Percent phonation time was analyzed by means of Newman's Technique as Tukey's procedure did not prove adequate to the analyses.

<sup>2</sup> Indicates significance at the .01 probability level (derived from tables of the normal deviate with 120 degrees of freedom).

<sup>3</sup> Indicates significance at the .01 probability level (derived from tables of the normal deviate with 120 degrees of freedom).

<sup>4</sup> This value is designated by Newman as  $q$  and the table value for eight means and 120 df for significance at the .05 confidence level is 4.290. Since  $4.301 > 4.290$ , significance was attained at the .05 level.

<sup>5</sup> The significance noted here existed only between passages F and H and not among any of the other passage means.

<sup>6</sup> In order to test for homogeneity of the remaining means, it was necessary to compute  $q$  ratios between all combinations of means; since none of these ratios reach a significant level homogeneity of the means is accepted.



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